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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|--|-------------|----------------------|---------------------------|------------------|
| 10/500,494 | 12/27/2004 | Hyung-Sang Park | 9907-007 | 4487 |
| 20995 7590 03/06/2007 KNOBBE MARTENS OLSON & BEAR LLP 2040 MAIN STREET FOURTEENTH FLOOR IRVINE, CA 92614 | | | EXAMINER PHAM, THANH V | |
| | | | ART UNIT 2823 | PAPER NUMBER |
| SHORTENED STATUTORY PERIOD OF RESPONSE | | NOTIFICATION DATE | DELIVERY MODE | |
| 3 MONTHS | | 03/06/2007 | ELECTRONIC | |

Please find below and/or attached an Office communication concerning this application or proceeding.

If NO period for reply is specified above, the maximum statutory period will apply and will expire 6 MONTHS from the mailing date of this communication.

Notice of this Office communication was sent electronically on the above-indicated "Notification Date" and has a shortened statutory period for reply of 3 MONTHS from 03/06/2007.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

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| | | | |
|------------------------------|-----------------|--------------|--|
| Office Action Summary | Application No. | Applicant(s) | |
| | 10/500,494 | PARK ET AL. | |
| | Examiner | Art Unit | |
| | Thanh V. Pham | 2823 | |

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 13 February 2007.
- 2a) ☐ This action is FINAL. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-3, 5-7, 9 and 21-24 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-3, 5-7, 9, and 21-24 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
 2. ☐ Certified copies of the priority documents have been received in Application No. _____.
 3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- * See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|--|---|
| 1) <input type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413) |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | Paper No(s)/Mail Date. _____ |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO/SB/08) | 5) <input type="checkbox"/> Notice of Informal Patent Application |
| Paper No(s)/Mail Date _____ | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 02/13/2007 has been entered.

Response to Amendment

Claim Rejections - 35 USC § 103

2. The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action.

3. Claims 1 and 6-7 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kirlin et al. US 6,320,213 B1 in combination with Soininen et al. US 6,482,740 B2.

Re claim 1, the Kirlin et al. reference discloses a method for forming copper interconnection conductor for interconnecting integrated circuits on a substrate 104, comprising:

forming a barrier layer 120 using Ru or Re or their alloys *directly on* a surface of an insulation/dielectric layer 112 on said substrate (fig. 11)

... materials that can be used ... include ... *nitrides ... amorphous nitrides ... noble-metal conductive alloys, such as ... Ru-Si-O, Ru-Si-N ... Re-Si-O, Re-Si-N ... All can be deposited from metalorganic precursors, in accordance with well known practice.* The diffusion barrier layer 120 is conductive and desirably permits little (low levels, preferably substantially no) diffusion of oxygen, platinum, copper or aluminum to occur (col. 6, lines 45-65).

and forming a copper layer 130 on said barrier layer 120 (col. 7, line 18).

The above limitations can also be recognized in figs. 22 and 24 wherein the same Ru or Re or their alloys (col. 9, lines 1-25) as barrier 230 is formed *directly on* the interlayer dielectric 218 and the metal layer 238 is formed on said barrier layer.

The Kirilin et al. reference discloses neither *using ALD* in forming the barrier layer of Ru or Re or their alloys nor *using CVD* in forming the Cu/metal layer.

The Soininen et al. reference discloses in fig. 1 a method for forming copper interconnect comprising:

forming a layer of ruthenium or ruthenium alloys by using an atomic layer deposition method

inert metals, such as platinum group metals, or conductive metal oxides, such as RuO₂, must be used adjacent to the high-k metal oxides (col. 4, lines 16-19).

the manufacture of conductive thin films, preferably comprising one or more of the following elements: *rhenium, ruthenium*, osmium ... iridium, nickel ... platinum ... a metal oxide layer by an ALD type process and essentially converting the metal oxide into an elemental metal to provide sufficient conductive for the thin film. A surprising finding related to the present invention is that the film has very good adhesion to the substrate, even after a reduction step (col. 5, lines 5-25).

...a substrate with open trenches and vias is provided into an ALD reaction chamber. ... A metal oxide thin film is grown on the diffusion barrier 14 from alternate pulses of a metal source chemical and oxygen source chemical... The metal oxide film is reduced into a metal layer and used as a seed layer 16 for an electroplating process (col. 7, lines 21-36);

and forming a copper layer 18 on the surface of said ruthenium or ruthenium alloys adhesion layer using CVD

alternatives for copper electroplating (step 9) are electroless plating, physical vapor deposition (PVD) and chemical vapor deposition (CVD). A seed layer (c.f. Step 8) is only needed for the electroplating process. Traditionally such a seed

layer is deposited by chemical vapor deposition (CVD) ... One can envision a seed layer that acts as a nucleation layer for the CVD process (col. 3, lines 15-35).

The Soininen et al. reference discloses forming the ruthenium or ruthenium alloys on another diffusion layer of nitride, it does not disclose forming the ruthenium or ruthenium alloys directly on the insulation layer.

It would have been obvious to one of ordinary skill in the art at the time of the invention to provide the method of Kirlin et al. with the techniques of ALD and CVD of Soininen et al. because the ruthenium or ruthenium alloys formed by ALD would provide the method with very good adhesion to the substrate and the copper CVD would provide the method with one of alternatives of forming conformal Cu layer (above passages from Soininen et al.)

Alternatively, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the method of Soininen et al. with the diffusion barrier layer of ruthenium or ruthenium alloys formed directly on the surface of the insulation layer because ruthenium or ruthenium alloys are compatible materials that can be used to substitute nitride barrier layer as recognized by Kirlin et al. to have substantially no diffusion of oxygen, platinum, copper or aluminum to occur (col. 6, lines 45-65 or col. 9, lines 1-25).

Re claim 6, the Soininen et al. reference discloses forming said copper layer further comprises using an electroplating method (step 9. Vias and trenches are filled with copper by an electroplating process, col. 3, lines 6-7).

Re claim 7, the Soininen et al. reference discloses forming said copper comprises sequentially using CVD followed by the electroplating method (the "alternatives" as extracted above).

4. Claims 2-3, 5, 9 and 21-24 are rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Kirlin et al./Soininen et al. as applied to claims 1 and 6-7 above, and further in view of Kim et al. US 6,936,535 B2, Koh et al. US 6,720,262 B2 and Gelatos et al. US 5,391,517.

The combination discloses substantially all of the instant invention but lacks the atomic ratio of ruthenium or rhenium in an alloy (re claims 2 and 9), PE-ALD (re claim 3) and iodine or an iodine compound as a catalyst for copper CVD (re claim 5) and CVD using a carbon-containing or fluorine-containing copper precursor or using a copper precursor comprising (hexafluoroacetylacetonate hfac) (Cu copper) (vinyltrimethylsilane vtms) (re claims 21-24).

Re claim 3, the Kim et al. reference discloses "the reactive metal layer may also be deposited by any method known in the art, such as by PVD, CVD, ALD or plasma enhanced ALD (PE-ALD) processes" (col. 10, lines 24-26).

It would have been obvious to one of ordinary skill in the art at the time of the invention to apply known plasma enhanced ALD (PE-ALD) processes because plasma enhanced ALD (PE-ALD) processes would provide the atomic layer deposition of the combination of Kirlin et al./Soininen et al. with an equivalent "self-limitingly, no more than a monolayer" at a time as taught by Kim (col. 9, lines 64-65).

Re claim 5, the Koh et al. reference discloses "in a first aspect of the present invention, a method of using iodine or bromine as a catalyst in conjunction with a copper CVD method in filling trenches, via holes and contacts without creating undesirable pinch-offs and voids is disclosed and presented" (col. 2 lines 45-53).

It would have been obvious to one of ordinary skill in the art at the time of the invention to provide the method of the combination with iodine as a catalyst in conjunction with a copper CVD because iodine as a catalyst in conjunction with a copper CVD would provide the method without creating undesirable pinch-offs and voids as taught by Koh et al.

Re claims 2 and 9, choice of ratio of elements would have been a matter of routine optimization because ratio of elements is known to affect device properties and would depend on the desired device density on the finished wafer and the desired device characteristics. One of ordinary skill in the art would have been led to the recited ratio of elements, 50% or more Ru or Re in the alloys, through routine experimentation to achieve desired deposition and reaction rates.

Re claims 21-24, the Gelatos et al. reference discloses (hexafluoroacetylacetonate hfac) (Cu copper) (vinyltrimethylsilane vtms) is used in CVD process to deposit copper into trenches.

It would have been obvious to one of ordinary skill in the art at the time of the invention to provide (hexafluoroacetylacetonate hfac) (Cu copper) (vinyltrimethylsilane vtms) as a carbon-containing or fluorine-containing copper precursor or a copper precursor comprising (hexafluoroacetylacetonate hfac) (Cu copper) (vinyltrimethylsilane

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vtms) because (hfac)Cu(vtms) would be selected in accordance with the Cu CVD process as taught by Kirlin et al./Soininen et al. The use of (hfac)Cu(vtms) as copper precursor (carbon-containing or fluorine-containing) for CVD is well known to those skill in the art as taught by Gelatos et al.

Response to Arguments

5. Applicant's arguments with respect to claim 1 and its dependents have been considered but are moot in view of the new ground(s) of rejection.

Conclusion

6. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

7. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Thanh V. Pham whose telephone number is 571-272-1866. The examiner can normally be reached on M-T (6:30-5:00).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Matthew Smith can be reached on 571-272-1907. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

02/28/2007

Michael L. Han
An 2823